

44-03

**ALTERNATE LINER SYSTEM MODIFICATIONS/
PERMIT TO CONSTRUCT**

FOR

**HAYWOOD COUNTY
MUNICIPAL SOLID WASTE LANDFILL FACILITY
PHASE 2**

WHITE OAK, NORTH CAROLINA

Project No. G98010

Carmen Johnson

Fac/Perm/Co ID # 44-07	Date 7/9/13	Doc ID# DIN
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October 2000

**Municipal Engineering Services Co., PA
Garner and Boone, North Carolina**

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October 24, 2000

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Re: **Alternate Liner System Modifications / Permit-to-Construct**
Haywood County Municipal Solid Waste Landfill – Phase 2
White Oak, North Carolina
MESCO Project No. G98010.6

Dear Mr. Sessoms:

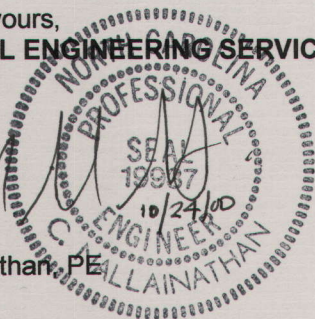
This letter presents the following additional information related to the alternate liner system modifications to the Permit-to-Construct for the above referenced project:

1. Section 2.2.6a Alternate Base Liner Calculations
2. Section 4.2.2a Alternate Base Liner System Specifications
3. Drawing Alternate Liner System Details

If you have questions or comments, please contact us at 919-772-5393.

Very truly yours,
MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

C. Nallainathan, PE



cc: Mr. Wayne Sullivan, MESCO

APPROVED
DIVISION OF WASTE MANAGEMENT
SOLID WASTE SECTION
DATE 1/26/01 BY BS (JB)
CF copy.

2.2.6a Alternate Base Liner Calculations

Geosynthetic Clay Liner (GCL) Calculations
Ref: CETCO Design Manual

FS	= factor of safety
T	= the allowable long-term tensile strength in the layer above the critical surface being analyzed.
L	= the slope length.
S	= the shear strength along the surface being analyzed.
β	= slope angle (degrees).
γ	= the unit weight of cover soil
z	= the thickness of the cover soil layer.
ϕ	= the internal or interface friction angle along the surface being analyzed.
C	= the apparent cohesion along the surface being analyzed.

$$FS = \frac{[(T+L) + S]}{[(z)(\gamma)(\sin \beta)]}$$

$$S = (\gamma)(z)(\cos \beta)(\tan \phi) + C$$

Check interface between cohesive soil liner and Bentomat (Reinforced GCL):

$$\begin{aligned}\phi &= 13.5^\circ \\ \gamma &= 110 \text{ lbs./ft}^3 \\ z &= 3 \text{ ft.} \\ \beta &= 18.4^\circ \text{ (3:1 slopes)}\end{aligned}$$

$$\begin{aligned}C &= 500 \text{ lbs./ft}^2 \\ T &= 90 \text{ lbs./ft.} \\ L &= 150 \text{ ft.}\end{aligned}$$

$$\begin{aligned}\therefore S &= (110)(3)(0.9489)(0.2401) + 500 \\ S &= 575.18 \text{ lbs/ft}^2\end{aligned}$$

$$\therefore FS = \frac{(90 \div 150) + 575.18}{(3)(110)(\sin 18.4^\circ)}$$

$$FS = 5.53 \text{ OK}$$

Check interface between Bentomat (Reinforced GCL) and 60 mil Textured HDPE Liner:

$$FS = \frac{[(T+L) + S]}{[(z)(\gamma)(\sin \beta)]}$$

$$S = (\gamma)(z)(\cos \beta)(\tan \phi) + C$$

$$\begin{aligned}\phi &= 13^\circ \\ \gamma &= 110 \text{ lbs./ft}^3 \\ z &= 3 \text{ ft.} \\ \beta &= 18.4^\circ \text{ (3:1 slopes)}\end{aligned}$$

$$\begin{aligned}C &= 200 \text{ lbs./ft}^2 \\ T &= 1,512 \text{ lbs./ft.} \\ L &= 150 \text{ ft.}\end{aligned}$$

$$\begin{aligned}\therefore S &= (110)(3)(0.9489)(0.2309) + 200 \\ S &= 272.29 \text{ lbs/ft}^2\end{aligned}$$

$$\therefore FS = \frac{(1,512 \div 150) + 272.29}{(3)(110)(\sin 18.4^\circ)}$$

$$FS = 2.71 \text{ OK}$$

4.2.2a Alternate Base Liner System Specifications

(1.1) General

This specification covers the technical requirements for the furnishing and installation of the Geosynthetic Clay Liner (GCL) described herein. All materials used shall meet the requirements of this specification, and all work shall be performed in accordance with the procedures provided herein and the contract drawings.

The Contractor shall furnish all labor, materials, supervision and equipment to complete the installation of the GCL, including, but not limited to, liner layout, seaming, patching, and all necessary and incidental items required to complete the Work, in accordance with the Contract Drawings and these Specifications.

Sufficient liner material shall be furnished to cover all lined areas shown on the Drawings, including overlaps at field seams and anchor trenches.

It is the intent of these Specifications to ensure a quality finished product. It shall be the responsibility of the Contractor to ensure that this requirement is met.

(1.2) Definitions

For the purposes of this specification guideline, the following terms are defined below:

Geosynthetic Clay Liner (GCL) - A manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetics. The GCL may be reinforced or unreinforced as required by site conditions. This site will require reinforced GCL over the entire area.

Geomembrane - An essentially impermeable geosynthetic composed of one or more geosynthetic sheets.

Geotextile - Any permeable textile used with foundation, soil, rock, earth, or any other geotechnical engineering related material as an integral part of a human-made project, structure, or system.

Minimum Average Roll Value - The minimum average value of a particular physical property of a material, for 95 percent of all the material in the lot.

Overlap - Where two adjacent GCL panels contact, the distance measuring perpendicular from the overlying edge of one panel to the underlying edge of the other.

(1.3) Submittals/Qualifications

- A. The GCL Manufacturer must have produced at least 10 million square feet (1 million square meters) of GCL, with at least 8 million square feet (800,000 square meters) installed. The manufacturer shall submit certification that GCL manufactured for the Project has been produced in accordance with these Specifications along with results from a quality control program. This information must be submitted for review prior to material delivery. The Engineer reserves the right to halt installation until proper certification is submitted and determined acceptable for use.

- B. The Contractor shall submit to the Engineer, six (6) full sets of panel layout construction drawings. Drawings shall be submitted to the Engineer at least two (2) weeks prior to installation.
- C. The manufacturer of the GCL used in this work shall approve all shop drawings and a proposed liner layout to cover the lined area shown on the Drawings.
- D. Details shall be included to show the termination of the liner at the perimeter of lined areas, the methods of sealing around penetrations, and methods of anchoring. A specific anchor trench detail shall be provided.
- E. The Contractor shall submit to the Engineer a physical sample of the liner to be used. The sample shall be labeled with the manufacturer's name, product identification, lot number and roll number.
- F. Upon shipment, the Contractor shall furnish the GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications to verify that the materials supplied for the project are in accordance with the requirements of this specification. The Contractor shall also submit to the Engineer inventory tickets, roll numbers or batch identifications, packing papers, and invoices for the liner used.
- G. As installation proceeds, the Contractor shall submit certificates of subgrade acceptance to the Engineer, signed by the Contractor and the GCL Installer for each area that is covered by the GCL.
- H. The Contractor shall provide personnel resumes demonstrating compliance with the following requirements.
 - 1. A project reference list for the GCL(s) consisting of the principal details of at least ten projects totaling at least 10 million square feet (100,000 square meters) in size.
 - 2. A minimum of one field superintendent per shift shall be designated by the Contractor and approved by the Engineer. Each field superintendent shall have a minimum of three years and five million square feet of field experience in installing GCL's. Any change or replacement of superintendent during the Project must be approved by the Engineer.
 - 3. Liner placement technicians shall have a minimum of one year and one million square feet of GCL placement experience.

(1.4) Construction Quality Assurance (CQA)

- A. The Project Engineer shall provide an inspector for CQA of the GCL installation. The inspector shall be responsible for observing and documenting activities related to the CQA of the GCL. The contractor shall not install any GCL on this project, at any time, in the absence of the CQA inspector.
- B. Testing of the GCL, as necessary to support the CQA effort, shall be performed by a third party laboratory retained by the Engineer and independent from the GCL manufacturer and installer.

(2) Products

(2.1) General

- A. The GCLs shall consist of a layer of natural sodium bentonite clay encapsulated between two geotextiles and shall comply with all of the criteria listed in this Section. Prior to using an alternate GCL, the Contractor must furnish independent test results demonstrating that the proposed alternate material meets all requirements of this specification. The Contractor also must obtain prior approval of the alternative GCL by the Project Engineer.
- B. Reinforced GCL must be used on all areas of the site.

(2.2) Materials

- A. An acceptable GCL product is Bentomat® ST as manufactured by CETCO or an engineer-approved equal.
- B. All areas of the project requiring reinforced GCL will be furnished with Bentomat® ST or an engineer-approved equal.
- C. The GCL(s) and their components shall have the properties shown in the attached CETCO's Technical Data Sheet (TR404bm).
- D. The minimum acceptable dimensions of full-size GCL panels shall be 150 feet (45.7m) in length and 15 feet (4.6m) in width for Bentomat. Short rolls [(those manufactured to a length greater than 70 feet (21m) but less than a full-length roll)] may be supplied at a rate of no greater than 3 per truckload or 3 rolls for every 36,000 square feet (3,500 square meters) of GCL, whichever is less.
- E. A 6-inch (150mm) overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.

(2.3) Product Quality Documentation

The GCL manufacturer/Contractor shall provide the Engineer with manufacturing QA/QC certifications for each shipment of GCL, prior to the deployment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager, and shall include:

- A. Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the parameters swell index and fluid loss shown in CETCO's Technical Data Sheet TR404bm.
- B. Manufacturer's test data for finished GCL products(s) of bentonite mass/area, GCL tensile strength, and GCL peel strength demonstrating compliance with the index parameters shown in CETCO's Technical Data Sheet TR404bm.

- C. GCL lot and roll numbers supplied for the project (with corresponding shipping information).

TR 404bn
Revised 11/9



COLLOID ENVIRONMENTAL TECHNOLOGIES COMPANY

TECHNICAL DATA SHEET

BENTOMAT "ST" CERTIFIED PROPERTIES

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY, ft ² (m ²)	REQUIRED VALUES
Bentonite Swell Index ¹	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss ¹	ASTM D 5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area ²	ASTM D 5993	40,000 ft ² (4,000 m ²)	0.75 lb/ft ² (3.6 kg/m ²)
GCL Grab Strength ³	ASTM D 4632	200,000 ft ² (20,000 m ²)	90 lbs (400 N)
GCL Peel Strength ³	ASTM D 4632	40,000 ft ² (4,000 m ²)	15 lbs (65 N)
GCL Index Flux ⁴	ASTM D 5887	Weekly	1 x 10 ⁻⁸ m ³ /m ² /sec
GCL Permeability ⁴	ASTM D 5084	Weekly	5 x 10 ⁻⁹ cm/sec
GCL Hydrated Internal Shear Strength ⁵	ASTM D 5321	Periodic	500 psf (24 kPa) typical

Bentomat "ST" is a reinforced GCL consisting of a layer of sodium bentonite between a woven and a non-woven geotextile which are needlepunched together.

Notes:

- ¹ Bentonite property tests performed at CETCO's bentonite processing facility before shipment to CETCO's GCL production facilities.
- ² Bentonite mass/area reported at 0 percent moisture content.
- ³ All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.
- ⁴ Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5x10⁻⁹ cm/sec for typical GCL thickness. This flux value should not be used for equivalency calculations unless the gradients used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.
- ⁵ Peak value measured at 200 psf (30 kPa) normal stress. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

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The information and data contained herein are believed to be accurate and reliable.

- D. Manufacturer's test data for finished GCL product(s) including GCL index flux, permeability, and hydrated internal shear strength data demonstrating compliance with the performance parameters shown in CETCO's Technical Data Sheet TR404bm.

(2.4) Material Conformance Testing

The CQA Engineer shall perform the material conformance tests listed in Table 1.

Table 1: QA Testing Program for GCL Material Conformance

PROPERTY	TEST METHOD	UNITS	VALUE ¹	TEST FREQUENCY
Hydraulic Conductivity	ASTM D5084 ²	cm/s	$\leq 5.0 \times 10^{-9}$	200,000 ft ²
Bentonite Content	ASTM D3776 ³	psf	0.75 (@0% moisture)	200,000 ft ²
Thickness	ASTM D1777	inch	0.20	200,000 ft ²
Grab Tensile Strength	ASTM D4632	lbs	90	200,000 ft ²
Interface Friction Test	ASTM D5321 ⁶	degrees	$\geq 13.5^4$	1
Interface Friction Test	ASTM D5321 ⁶	degrees	$\geq 13.0^5$	1
Shear Strength	ASTM D5321	psf	500	1

¹ Minimum Average Roll Values (MARV).

² Conduct test at 5 psi effective stress.

³ Alternatively, use ASTM D5993 for measuring the mass per unit area of GCL.

⁴ GCL against the soil liner (peak value).

⁵ GCL (woven geotextile) against the textured FML (peak value).

⁶ Conduct test at 3 psi effective stress and hydrate the GCL.

Samples for material conformance testing shall be obtained upon delivery of the GCL. Samples shall be taken across the entire width of the roll. Samples shall be 1 foot to 3 feet long by the roll width. All material conformance testing shall be performed by a third party Geosynthetics Laboratory retained by the Engineer. All test results must be available at the Engineer's office prior to the deployment of any GCL roll at the site. The CQA Engineer will examine all results from laboratory testing.

(2.5) Product Labeling

- A. Prior to shipment, the GCL manufacturer shall label each roll, identifying:
1. Product identification information (Manufacturer's name and address, brand name, product code).
 2. Lot number and roll number.
 3. Roll length, width, and weight.

(2.6) Packaging

- A. The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.
- B. All rolls shall be labeled and bagged in packaging that is resistant to photodegradation by ultraviolet (UV) light.

(2.7) Accessory Bentonite

- A. The granular bentonite or bentonite sealing compound used for seaming, penetration sealing, and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer.

(2.8) Equipment Requirements

- A. CETCO GCLs are delivered in rolls weighing from 2,500 - 2,700 lbs (1,140-1,225 kg). It is necessary to support this weight using an appropriate core pipe. For any installation, the core pipe must not deflect more than 3 inches (75 mm) as measured from end to midpoint when a full GCL roll is lifted.
- B. Lifting chains or straps rated for at least twice the load of the GCL should be used in combination with a spreader bar made from an I-beam. The spreader bar ensures that the lifting chains or straps do not chafe against the ends of the GCL roll, which must be able to rotate freely during installation.
- C. A front end-loader, backhoe, dozer, or other equipment can be furnished with the spreader bar and core bar. Alternatively, a forklift with a "stinger" attachment may be used for on-site handling and, in certain cases, installation. **A forklift without a stinger attachment shall not be used to lift or handle the GCL rolls.**
- D. When installing over certain geosynthetic materials, a 4-wheel all-terrain vehicle (ATV) can be used to deploy the GCL from behind. An ATV can be driven directly on the GCL provided that no sudden stops, starts, or turns are made.
- E. Additional equipment needed for installation of CETCO's GCLs includes:
- Utility knife and spare blades (for cutting the GCL).
 - Granular bentonite or bentonite mastic (for overlapped seams of GCLs with needle punched non-woven geotextiles and for sealing around structures and details).

- Waterproof tarpaulins (for temporary cover on installed material as well as or stockpiled rolls).
- Optional chalk line marker to simplify bentonite placement at seams (when installing a GCL with needlepunched non-woven geotextile components).
- Optional flat-bladed vise grips (for positioning the GCL panel by hand).

(3) EXECUTION

(3.1) Shipping and Handling

- A. The manufacturer assumes responsibility for initial loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling, and storage of the GCL are the responsibility of the Contractor, Installer, or other designated party.
- B. A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.

The party responsible for unloading the GCL should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.

(3.2) Storage

- A. Storage of the GCL rolls shall be the responsibility of the installer. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry, and well-drained.
- B. Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or by use of the dunnage shipped between rolls. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four). Rolls shall never be stacked on end.
- C. All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.
- D. The integrity and legibility of the labels shall be preserved during storage.

(3.3) Earthwork/Subgrade Preparation

- A. Any surface upon which the GCL is installed shall be prepared and compacted in accordance with the project specifications and drawings. The surface shall be smooth, firm, and unyielding, and free of vegetation, any debris, sticks, sharp rocks, void spaces, ice, abrupt elevation changes, standing water, cracks larger than one-quarter inch (6mm) in width, and any other foreign matter that could contact the GCL.
- B. Subgrade surfaces consisting of granular soils or gravel may not be acceptable due to their large void fraction and puncture potential. Subgrade soils should

possess a particle size distribution such that at least 80 percent of the soil is finer than a No. 60 sieve (0.250 mm).

- C. Immediately prior to GCL deployment, the subgrade shall be final-graded to fill in all voids or cracks and then smooth-rolled to provide the best practicable surface for the GCL. At completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the subgrade. Furthermore, all protrusions extending more than one-half inch (12mm) from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor.
- D. On a continuing basis, the Contractor/GCL Installer shall submit certifications of subgrade acceptance to the Engineer, and the project CQA inspector shall verify acceptance of the subgrade before GCL placement.
- E. It shall be the installer's responsibility thereafter to indicate to the Engineer any change in the condition of the subgrade that could cause the subgrade to be out of compliance with any of the requirements listed in this Section.
- F. At the top of sloped areas of the job site, an anchor trench for the GCL shall be excavated in accordance with the project plans and specifications. The excavated trench shall be verified by the CQA Inspector prior to GCL placement. No loose soil shall be allowed at the bottom of the trench and no sharp corners or protrusions shall exist anywhere within the trench.

(3.4) GCL Placement

Placement of the GCL shall be conducted in accordance with the manufacturer's recommendations and with the direction provided herein. Any deviations from these procedures must be pre-approved by the CQA Engineer.

- A. The contractor shall not install any GCL on this project, at any time, in the absence of the CQA inspector. During start-up of the GCL installation, an agent or representative of the Manufacturer shall provide on-site assistance and instruction to the Contractor and CQA Engineer regarding the appropriate installation techniques.
- B. The CQA Inspector/Engineer shall inspect each panel, after placement and prior to seaming, for damage and/or defects. All defects and deficiencies shall be properly documented by the GCL Installer and CQA Inspector. Defective or damaged panels shall be replaced or repaired, as approved by the CQA Inspector/Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the Engineer. The CQA Inspector shall observe and verify all repaired defects.
- C. Reinforced GCL shall be placed on all areas of the site.
- D. GCL rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) may be important if the GCL has two different geotextiles. Unless otherwise specified, however, the GCL shall be placed with the white side (non-woven) geotextile facing down.
- E. The GCL shall be properly weighted to avoid uplift due to wind.

- F. Equipment which could damage the GCL shall not be allowed to travel directly on it. Acceptable installation, therefore, may be accomplished such that the GCL is unrolled in front of the backwards-moving equipment. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues. Equipment necessary to perform the installation (generators, compressors, etc.) shall have a scrap GCL sheet placed underneath to protect the installed GCL from possible damage.
- G. The GCL shall be kept free of debris, unnecessary tools and materials. In general, the GCL area shall remain neat in appearance. All damage shall be recorded and located in the record drawings.
- H. Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering commonly known as a slip sheet or rub sheet may be used to reduce friction damage during placement.
- I. The GCL shall be placed so that seams are parallel to the direction of the slope. End-of-roll seams should be located at least 3 feet (1m) from the toe and crest of slopes steeper than 4H:1V. GCL rolls shall not be released on the slope and allowed to unroll freely by gravity.
- J. All GCL panels shall be placed free of tension or stress and lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels. Similarly, the geomembrane placed over GCL shall lie flat and in contact with the underlying GCL with no wrinkles or fold.
- K. The GCL shall not be installed in standing/ponded water, during rainy weather/precipitation, excessive moisture, and during extremely/excessive high wind. Only as much GCL shall be deployed as can be covered at the end of the working day with the geomembrane. In no case shall the GCL be exposed to the elements at the end of the day. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it will be necessary to remove and replace the hydrated material. The project Engineer, CQA inspector, and GCL supplier should be consulted for specific guidance if premature hydration occurs.
- L. The GCL shall not get wet before or during installation. The GCL mat shall not be installed during periods of any precipitation. If a precipitation event occurs after the installation of a GCL panel, but prior to covering with the geomembrane panel, a thin film plastic sheeting may be used to cover and to temporarily protect the GCL from moisture, if approved by the Project Engineer.
- M. Panels shall be placed from the highest elevation to the lowest within the area to be lined, to facilitate drainage in the event of precipitation.
- N. It is not permissible to stretch the GCL in order to fit a designated area. Panels shall not be dragged across the subgrade into position except where necessary to obtain the correct overlap for adjacent panels.

(3.5) Anchorage

- A. As directed by the project drawings and specifications, the end of the GCL roll shall be placed in an anchor trench at the top of the slope. The front edge of the

trench should be rounded so as to eliminate any sharp corners. The GCL should cover the entire trench floor but does not extend up the rear trench wall.

- B. The amount of trench open at any time shall be limited to one day of GCL installation capacity. The anchor trench shall be adequately drained to prevent water ponding and softening the adjacent soils. Loose soil shall be removed from the floor of the trench. The soil backfill should be placed in the trench to provide resistance against pullout. The size and shape of the trench, as well as the appropriate backfill procedures, should be in accordance with the project drawings and specifications.

(3.6) Seaming

- A. The GCL seams are constructed by overlapping their adjacent edges. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Supplemental bentonite is required for Bentomat® ST.
- B. The minimum dimension of the longitudinal overlap should be 6 inches (150 mm). End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 24 inches (600 mm). In the opinion of the CQA Engineer/Inspector, any seam, or edge of GCL material exposed for more than 24 hours or considered partially hydrated when seaming occurs shall receive a 3-foot overlap (rainlap) from the adjoining GCL panel.
- C. All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be seamed.
- D. Seam areas or runs shall also be flat and clear of any large rocks, debris, or ruts. Contacting surfaces shall be clean and clear of dirt or native soil with all edges pulled tight to maximize contact and to smooth out any wrinkles or creases.
- E. All seams constructed on sloped surface shall be vertical seams.
- F. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.
- G. Bentonite-enhanced seams are constructed between the overlapping adjacent panels described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6 inch (150 mm) line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap. The bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot (0.4 kg/m).

(3.7) Detail Work/Sealing Around Penetration and Structures

- A. Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid irregular tearing of the geotextile components of the GCL during the cutting process. The GCL shall be sealed around penetrations and structures embedded in the subgrade. Granular bentonite or a bentonite mastic shall be used liberally (approximately 2 lbs/in ft or 3 kg/m) to seal the GCL to these structures.

- B. When the GCL is placed over an earthen subgrade, a "notch" (approximately 3 inches wide and 8 inches deep) shall be cut against the edge of the subgrade area around the penetration. The mat shall be brought up to the edge of the structure and trimmed to fit into the notch. The Contractor shall then hand apply a pure bead of bentonite into half the notch. The mat shall then be inserted into the notch, with the remaining volume of the notch refilled with the pure bentonite and compacted.
- C. A secondary collar of GCL should be placed around the penetration. It is helpful to first trace an outline of the penetration on the GCL and then cut a "star" pattern in the collar to enhance the collar's fit to the penetration.
- D. Vertical penetrations are prepared by notching into the subgrade. The penetration is completed with two separate pieces of GCL. A secondary collar is option in this case.
- E. When the GCL is terminated at a structure or wall that is embedded into the subgrade, the subgrade should be notched as described in Items B and D above. The notch is filled with granular bentonite, and the GCL should be placed over the notch and up against the structure. The connection to the structure can be accomplished by placement of soil or stone backfill in this area.

(3.8) Damage Repair

- A. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that minimum overlap of 12 inches (300 mm) is achieved around all of the damaged area. Dry bentonite or bentonite mastic should be applied around the damaged area at the rate of one-half pound per lineal foot prior to placement of the patch. Any epoxy-based adhesives shall be used to keep the patch in position during backfill operations.

(3.9) Placement of Overlaying Materials

- A. Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles [such as 4-wheel all-terrain vehicles (ATV)] may be used to facilitate the installation of any geosynthetic material placed over the GCL, provided the ATV makes no sudden stops, starts, or turns. The GCL supplier or CQA engineer should be contacted with specific recommendations on the appropriate procedures in this situation.
- B. When a textured geomembrane is installed over the GCL, a temporary geosynthetic covering known as a slip sheet or rub sheet should be used to minimize friction during placement and to allow the textured geomembrane to be more easily moved into its final position.
- C. Any leading edge of panels left uncovered shall be protected at the end of the working day with a waterproof sheet which is adequately secured with sandbags or other ballast.
- D. Soil cover shall be placed over the GCL/geomembrane using low ground pressure construction equipment that minimizes stresses on the GCL/geomembrane, according to the existing project specification requirements for protective cover soil installation over geomembrane liner.

